

## REMARKS

Claims 1-14 are pending in the present application. All claims are in condition for allowance for the reasons set forth herein.

### Claim Rejections - 35 USC § 103

Claims 1 and 10-14 are rejected under 35 U.S.C. 103(a), as being unpatentable over Wehrmann et al. in view of Gallagher et al.

The Office opines that Wehrmann et al. discloses a method for manufacturing a thin light emitting diode but fails to teach a ZnS doped with a luminescent center by precipitation from aqueous solutions. Gallagher et al. is cited for teaching the doping method. Applicants respectfully submit that one of skill in the art would not be expected to combine these references due to the incompatibility of the teachings therein.

According to claim 1 of Wehrmann et al. the electroluminescent element contains at least a hole transport zone and an adjacent hole injection zone. Wehrmann et al. at paragraph [0059] discloses:

"As luminescent material (component C), it is possible to use substances which display photoluminescence, i.e. fluorescent and laser dyes, but also metal complexes and chelates or inorganic nanosize particles. "

and at paragraph [0062] discloses:

"Suitable inorganic nanosize particles are, for example, semiconductors such as CdS, CdSe, ZnS or ZnO"

Therefore, Wehrmann et al. only discloses fluorescent ZnS nanosize particles. Wehrmann et al. does not mention doped ZnS, nor do they provide a preparation process for doped ZnS nanoparticles capable of emitting light under the influence of direct current.

Gallagher et al. discloses in claim 1 that:

"A chemically doped precipitated particle of semiconductor material of less than 100Å in diameter encapsulated with a surfactant, the surfactant maintaining a quantum confinement of said particle and further providing a surface passivation of said particle, the dopant concentration of said particle being 0.5-1.0%."

and at col. 2, lines 15-29, Gallagher et al. discloses that:

"Most homogeneous precipitation of nanometer sized undoped particles has used an aqueous salt chemistry (e.g.  $\text{Zn}(\text{ClO}_4)_2 + \text{NaHS} \rightarrow \text{ZnS}$  in water). The present methodology uses an organometallic chemistry in a hydrocarbon solvent. See, e.g., Johnson et al (C. E. Johnson, D. K. Hickey, and D. C. Harris, "Synthesis of Metal Sulfide Powders From Organometallics," Mat. Res. Soc. Symp. Proc. Vol 73, 785-789, 1986) wherein 0.1 µm undoped ZnS particles (not quantum sized) were produced in organic solvents. The attraction of this chemistry is that the powders are highly crystalline and had very low residual organic content (<60 ppm alkane). In the present development, by controlling the physical process parameters, a similar chemistry can be used to make quantum sized particles (<50Å). However the particles must also be doped."

Gallagher et al. specifically teaches that undoped particles are precipitated in water. However, Gallagher et al. discloses that organometallic chemistry is employed when doping

is required. This teaches away from the combination of doping and aqueous precipitation.

Gallagher et al. further teaches the use of a Grignard reagent. It is widely known that Grignard reagents react with water. Gallagher et al. clearly states in col. 3, line 56, to col. 4, line 14:

"A flowchart of the process is presented in FIG. 1. The starting solution at step 20 contains pure diethylzinc ( $(C_2H_5)_2 Zn$ , CAS number [557-20-0]) dissolved in toluene (Anhydrous,  $C_6H_5CH_3$ , CAS no. [108-88-3]) so that the final reaction concentration of zinc is  $5 \times 10^3$  M. The diethylzinc can also be obtained by a Grignard reaction. The surfactant, poly(methyl methacrylate) (medium molecular weight powder, approximately 145,000),  $[H_2C=C(CH_3)(COOCH_3)]_n$ , CAS no. [9011-14-7], (0.28 g dissolved in 20 ml toluene)), is added to the diethylzinc solution at step 22. It takes approximately 12-18 hours for the PMMA to dissolve.

Separately, the diethylmanganese was prepared by the Grignard reaction of 1.3 ml of manganese chloride ( $MnCl_2$ , CAS no. [7773-01-5] (0.122g dissolved in 17ml tetrahydrofuran at step 24)) (anhydrous,  $C_4H_8O$ , CAS no. [109-99-9]) with 10 ml of ethylmagnesium chloride (2.0M solution in tetrahydrofuran,  $C_2H_5MgCl$ , CAS no. [2386-64-3], (diluted 1:100 in tetrahydrofuran at step 26)). This amount of manganese would correspond to approximately 10 atomic % if all manganese chloride was converted to diethylmanganese and all was incorporated in the ZnS. A stoichiometric excess of ethylmagnesium chloride is used to drive the reaction at step 28 to completion. The reaction product is orange in color but turns brown with time - as the diethylmanganese decomposes."

The reagents used in Gallagher et al. include anhydrous toluene, anhydrous tetrahydrofuran and other reagents.

This is consistent with the use of Grignard reagents. The Office has argued that this same text discloses precipitation from aqueous solution. Applicants contend that it is improper to extract teachings of aqueous

precipitation from anhydrous solvents. This is especially improper in view of the teaching in Gallagher et al. that aqueous precipitation is used without doping while organic precipitation is used with doping.

Wehrmann et al. fails to teach aqueous precipitation and Gallagher et al. teaches doping in an anhydrous organic solvent solution using Grignard reagents which decompose upon contact with water. The Office has argued that this combination renders the present claims obvious under 35 U.S.C. §103(a) despite its failure to teach the claimed invention and its containing teachings which clearly teach away from the present invention.

We therefore contend that claim 1 and claims 10 to 14 are patentable under 35 USC § 103(a) over Wehrmann et al. in view of Gallagher et al.

Wehrmann et al. and Gallagher et al. can not be combined since Wehrmann et al. is specific to an aqueous system and Gallagher et al. relies on chemistry which fails in aqueous chemistry. Applicants respectfully submit that the rejection of claims 1 and 10-14 as being unpatentable under 35 U.S.C. § 103(a) over Werhmann et al. in view of Gallagher et al. is improper. Removal of the rejection is respectfully requested.

Claims 2-9 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Wehrmann et al. and Gallagher et al. as discussed in reference to claim 1 and further in view of Gray et al.

The Office opines that, at the time the invention was made, it would have been obvious to one of ordinary skill in the art to combine dopant ions from the teachings of Gray et al. with Wehrmann et al., because it would have prevented the agglomeration and achieved high purity and improved the photoluminescence as taught by Gray et al.

The Office also opines that, at the time the invention was made, it would have been obvious to one of ordinary skill in the art to use the doped ZnS teaching method of Gallagher et al. with Wehrmann et al., because it would have created faster light emitting material as taught by Gallagher et al.

The inapplicability of Wehrmann et al. and Gallagher et al. has been addressed above and also applies to these rejections. Gray et al. discloses in claim 1:

"Nanocrystalline phosphors comprising a binary II-VI semiconductor host compound doped with Mn; Cu; Ag; Eu; Cu,Cl; Cu,Tb; Tb; Ag,Cl; Cl; Cu,Al; Ce; Er, Er,Cl; or Zn, wherein said doped nanocrystalline phosphor has an average of about one or less dopant ion per nanocrystalline phosphor particle."

at col. 2, lines 26-42, that:

"The present invention is based upon the availability of stable mesoporous structure provided by

Bicontinuous Cubic Phase (BCP) of lipids in the temperature range of 20-100°C. The formation of nanoparticulate materials is achieved by chemical reactions among precursors which are either all or in part embedded within the cubic matrix, or by physical transportation of one or more of the precursors from the outside environment into the mesoporous structure. The size of the grown crystals is limited by the size of the pores in the matrix and/or by chemical termination achieved by the limited amount precursor(s) available within the matrix. The solubility of surfactant in wide variety of solvents facilitates simple isolation and purification of formed nanoparticles from surfactant and remnant precursor chemicals. The stoichiometric composition of the nanoparticle can be controlled very accurately via the relative concentration of the precursor ions."

and at col. 2, line 62, to col. 3, line 52, that:

"Any combination of surfactant and liquid hydrophilic phase, at any ratio that produces a bicontinuous cubic phase, may be employed. As stated earlier the formation of bicontinuous phases has been well characterized in the prior art. Thus, the specifics of forming the bicontinuous phase will not be discussed here.

Bicontinuous cubic phases include mesoporous cavities that are interconnected by channels. The cells and the channels interconnecting the cells are filled with the liquid hydrophobic phase. In the present application, the liquid hydrophilic phase is typically exemplified by an aqueous phase. Another liquid hydrophilic phase such as ethanol or methanol however may be used in place of an aqueous phase according to the present invention. Thus, unless otherwise stated, teaching in the present application relating to the use of an aqueous phase are applicable to the use of any liquid hydrophilic phase used in place of an aqueous phase.

The size of the mesoporous cavities in a bicontinuous cubic phase is controlled, in an art-known and recognized manner, by selection and concentrations of the aqueous (or non-aqueous) phase and surfactant. Typically, mesoporous cavities (aka "pores") in a bicontinuous cubic phase have a diameter of about 2 nm to about 30 nm, and more often about 2.5 to about 10 nm. Of course, the only upper limit on the size of the mesoporous cavities useful in the method of the present invention is that they must be sufficiently small to restrict the diameter of semiconductor particles grown therein to about 30 nm or less. Therefore, bicontinuous cubic phases having mesoporous cavities as large as about 30 nm are useful according to the present invention.

Surfactants used to form the BCP structure have at

least one long chain ( $C_8$  or above) hydrophobic (typically allyl) chain and at least one polar head group. These surfactants may be glycerated or non-glycerated, and may be nonionic, amphoteric, anionic, or cationic. These surfactants may also be lipids. Some typical surfactants useful in forming bicontinuous cubic phases include sodium diethyl hexylsulphosuccinate (AOT), potassium octanoate decyltrimethylammonium chloride, dodecyltrimethylammonium chloride and mono-1-olein hexadecyllysophosphatidylcholine.

The reactants used to form the semiconductor particles should be soluble in the phase (i.e. hydrophobic chain of the surfactant, the aqueous phase of a non-inverted bicontinuous cubic phase, or the non-aqueous phase of an inverted bicontinuous cubic phase) which fills the pores of the bicontinuous cubic phase and should react, in solution to form semiconductor particles that are insoluble in the pores of the bicontinuous cubic phase.

To form semiconductor particles according to the method of the present invention, at least one of the reactants required to form the semiconductor compound but less than all of the required reactants, are usually included in the surfactant or aqueous phase used to make the bicontinuous cubic phase, so that the latter formed bicontinuous cubic phase includes that at least one reactant in solution within its pores. The remaining required reactants are then diffused into the pores of the bicontinuous cubic phase. Once these remaining materials diffuse into the pores, they react with the at least one reactant to form the desired semiconductor particles."

The disclosure of Gray et al. complicates the combined teachings of Wehrmann et al. and Gallagher et al. If the teaching of Gray et al. were to be incorporated into the combined teachings of Wehrmann et al. and Gallagher et al. the activity of the Grignard reagent of Gallagher et al. would be compromised due to its reaction (hydrolysis) with water. If an anhydrous solution were to be incorporated as disclosed in Gallagher et al. the bicontinuous phase of Gray et al. would be rendered ineffective.

If Gallagher et al. were to be substituted for Gray et al. the claims are not rendered obvious, since Wehrmann et al. fails to disclose ZnS doped with a luminescent center by precipitation from appropriate aqueous solutions comprising zinc ions, sulfide ions and dopant ions and washing dispersions of doped ZnS to remove non-precipitated ions, Gray et al. does not teach those elements lacking in the disclosure of Wehrmann et al.

The technique of Gray et al. is not a precipitation technique, as set forth in the claimed invention, but is instead a two phase system wherein one phase is a bicontinuous cubic phase and the other phase is a solution. The formation of a doped ZnS occurs by some undescribed phenomenon involving the interior surface of the bicontinuous cubic phase and reactants which enter therein. The present invention is specific to an aqueous precipitation wherein all the reactants are brought together to form a doped ZnS particle.

Col. 4, lines 1-7 of Gray et al. are cited as forming a precipitation from an aqueous phase. This disclosure is taken out of context based on the teachings of the present invention. The disclosure of Gray et al. describes a process wherein the reactants are maintained in an aqueous phase below a reaction temperature to prohibit precipitation until the bicontinuous cubic phase can be added into the solution. The reactants then diffuse into the interior of the bicontinuous cubic phase for



reaction to occur. It is clear from the teachings of Gray et al. that precipitation directly from aqueous solution is undesirable.

It is only in hindsight, based on the present application, that the teachings of Gray et al. would be considered. Even then critical elements must be ignored to reach a finding of unpatentability. If the teachings of Gray et al. are followed precipitation from aqueous solution is to be avoided. This is contrary to the present claimed invention.

In making the present rejection the Office has considered Wehrmann et al., which does not teach doped ZnS, combined with Gray et al., which teaches away from precipitation in aqueous solution. The present invention is directed to a doped ZnS, prepared by precipitation directly from aqueous solution. This rejection can only be made in hindsight which is improper.

Finally, the Office alluded to the techniques used for washing and cleaning as being standard techniques. However, it is not the fact that the techniques used are standard techniques which is important, it is the way and combination in which they are used to solve a particular preparation problem that is important, in this case the synthesis of quantum-confined manganese-doped zinc sulfide nanoparticles, which are apparently so difficult to prepare in aqueous media that Gallagher et al. had to resort to unconventional non-aqueous preparation

techniques requiring the synthesis and use of more exotic ingredients.

We therefore contend that the inventions of present claims 2-9 of the present application cannot be adduced by combining the teachings of Wehrmann et al., Gallagher et al. and Gray et al. Hence, claims 2-9 are patentable under 35 U.S.C. §103(a) over Wehrmann et al. in view of Gallagher et al. and Gray et al. Furthermore, claims 2-9 being dependent upon claim 1 which is, as argued above, inventive over Gallagher et al. in view of Wehrmann et al. claims 2 to 9 are also inventive under 35 U.S.C. §103(a).

### CONCLUSIONS

Claims 1-14 are pending in the present application. All claims are in condition for allowance. A notice of allowance for claims 1-14 is respectfully requested.

Respectfully submitted,

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